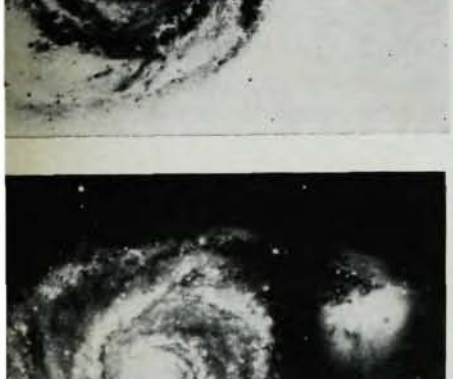
RESEARCH FACILITIES AND PROGRAMS

Cosmology with antimatter

Hannes Alfvén proposes that the origin of the universe was a tenuous "ambiplasma" composed of matter and antimatter. He treats this new cosmology at some length in a recent issue of *Reviews of Modern Physics* [**37**, 652 (1965)]. The ambiplasma (Professor Alfvén's word) would have been a gas of protons, electrons, antiprotons, and positrons subject to self-gravitation and electrical and magnetic forces. If the composition of the ambiplasma were symmetric, these forces would separate the ambiplasma into three kinds of regions: one exclusively matter, one exclusively antimatter, and a buffer region of ambiplasma serving to keep the two others apart. Professor Alfvén argues that regions of the same content would attract each other but repel those of opposite content, and therefore larger and larger regions of matter and antimatter would coalesce.



Alfvén cosmology suggests that galaxies of antimatter may exist in equal number with galaxies of matter.

The buffer layers would act like the "Leidenfrost" layer that appears when liquid drops are in contact with a very hot (over 100°C) surface such as a frying pan. This is a layer of vapor that serves to insulate the droplet from the hot surface, thereby allowing it to remain for several minutes instead of vaporizing immediately. In the plasma analogy, at the interface between matter and antimatter annihilations produce a very hot layer that serves to keep the two regions apart just as the Leidenfrost layer keeps the liquid water from actually touching the hot pan.

But if the universe is half matter and half antimatter, where has the separation process put the concentrated antimatter? We know that the immediate neighborhood of the earth is made of matter. Rockets colliding with the moon have yielded no violent explosions, and cosmic-ray evidence would lead to the assumption that there is no significant antimatter between here and the nearest stars. Beyond that there is no direct evidence. Since there is no way to tell whether given electromagnetic radiation comes from antimatter or matter (we don't know the orientation of the magnetic fields that may be in the neighborhoods of distant stars), every second star in the galaxy could be made of antimatter. It might then be that alternate arms of a spiral galaxy were of matter and antimatter.

It is also compatible with the Alfvén theory for our galaxy to be entirely matter; the antimatter then gets concentrated in other galaxies, and the division between galaxies and antigalaxies would be one to one. Furthermore, it might even happen that all the galaxies we can see are made of matter. These galaxies form a system, which Professor Alfvén (following Oskar Klein) calls a "metagalaxy", and it is conceivable that other metagalaxies should exist for antimatter to reside in.

According to the theory a metagalaxy will condense until disruptive forces overbalance condensing ones (in this condition it has finite volume and density), and it begins to fly apart. Therefore, it is not the universe that is expanding but our own metagalaxy, which happens to be some time past its turning point and engaged in an expanding phase. This turns out to be possible according to Professor Alfvén's dynamic equations as long as the proper age is put into them. Of course, any other metagalaxy that was in its expanding phase would look like our own; one of the tests of the theory would be evidence of a condensing one.

Professor Alfvén seeks to determine whether evidence of existence might be given by the systems he postulates. An ambiplasma, he figures, would emit photon radiations at various energies as a result of both annihilation and synchrotron processes. If the proper conditions of density and magnetic field are present, some of the synchrotron radiation should be strong enough to be observed. (In the Leidenfrost layers, these conditions would not be met; in the original ambiplasma, they could be.) He is less sanguine about the possibility of seeing a condensing metagalaxy. Such a system should be very dark. It might reabsorb all the radiation it produces, but, even if it does not, the amount that escaped would be small and very weak.

On the whole, Professor Alfvén seems to prefer to separate the matter and antimatter in different metagalaxies (with even representation of both sides). He suggests that there may be an infinity of them scattered through a space that is infinite and unbounded. Cosmic geometry may be Euclidian after all; the Einsteinian geometry that we see is perhaps a local effect of the composition of our own metagalaxy.